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Assessment of TRIZ potential on companies Innovation Capacity, Illustration with the Hybrid Boiler designed at Bosch Thermotechnology

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Abstract

Innovation is one of the aims of many organisations. It is a mandatory condition for durable industrial activities, even though it bears specific issues, such as the involvement of substantial resources, temporary low profitability, high risks and failure rates, which need to be overcome to succeed. Therefore we investigated the notion of innovation performance, as it is critical to analyse the reach of organisational innovation-related objectives and the allocation and use of resources.
The measurement of such a performance is generally done through the observation of organisation Research and Development (R&D) investments as well as the quantity of patent applications. However, it was shown that even if the R&D investments are an assessment element of the innovation process inputs, the patents do not show a fair image of the innovation capacity, namely because of their relative value and use [1]. Some authors focused on the assessment of the innovation capacity (or innovation potential), studying the factors that enable innovation. We propose to synthesise the fields covered by these factors and will investigate two of the most advanced models that offer different approaches and perspectives [2], [3].
Based on these elements, we analyse the interactions between classical TRIZ and the organisational innovation capacity factors in order to determine TRIZ potential. This methodological and theoretical approach is then confronted to a field example: the design of a hybrid-heating appliance (compact electrical heat-pump combined with a gas condensing boiler) within Robert Bosch company. This study is marked by the context of regulation evolutions such as the European Directive on Energy-related Products (ErP) and strong technical challenges to overcome. Results shows the outcomes that companies can expect out of TRIZ, which are seen as vectors of expansion for the understanding and the use of the theory in the industrial world. It also emphasizes what are the points that cannot be covered by classical TRIZ within all the different fields of the innovation capacity (Strategy, Organisation, Process, Resources, Tools and Culture). The reasons for the deviations between theoretical approach and the studied case are analysed and perspectives are given on a new approach combining TRIZ and the Blue Ocean Strategy.

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1. Introduction

Many organisations aim towards innovation. It became a mandatory condition for long-lasting industrial activities, but contains issues and challenges to be overcome to manage it. Among these, we noted the one of its performance. It is indeed critical to assess the achievements of company objectives related to innovation and the resources it requires. These elements allow checking that the organisation improves enough with regards to the dedicated effort and priority given to innovation.

1.1. The stakes of innovation

Groff defines innovation as the "capacity to create value by bringing something new in a given field while assuring an optimal acceptance of this novelty" [4]. This notion relies on:

- Creativity (novelty generation)
- Value (of esteem, use or trade)
- Social acceptance (change management)

Some authors [5] propose that the ability to innovate represents for an organisation its ability to survive, or [6], [7] consider that innovation is the key of success of the company and some others [8] that it is the only alternative. Therefore, all of them assume that innovation gives a competitive advantage.

However, the relationship between innovation and company performance is the purpose of controversial empirical analysis. It is indeed legitimate to look for proof of its benefits, because innovation requires a substantial amount of resources [9] that can exceed the capacity of some companies [10],[11],[12]. Furthermore, innovation increases uncertainty and risks [13], [14] and result in high failure rates [15],[16]or temporary low profitability [17].

Rosenbusch et al. established within a synthesis of the results of 42 surveys on 21270 companies [18] the nature of the link between innovation and company performance and especially the role of influence factors such as the age of the company, the type of innovation considered and its cultural context. Their conclusions are that:

- Companies have a benefit in the increase of the outcome of the innovation process compared to the allocated resources, which is a claim for a better understanding of how the process inputs (essentially resources and information) can be transformed efficiently into marketable outputs.
- In order to benefit from innovation, resources must be dedicated to it and their conversion into an innovative offer must be managed efficiently.

However, even though the company interest is understood, innovation is not, by nature, a trivial process. The greatest barriers for its embodiment stem from the fact that innovation is a result and it is actually the organization innovation capacity that needs to be constructed, and not only in exceptional projects, but continuously[19],[20],[21],[22].

We will now have a look at the available means to assess this ability.

1.2. Innovation performance assessment

Several ways are used to give an image of innovation performance. These can be quantitative or qualitative and result partly into indicators such as the market shares won thanks to innovative or technology-intensive products or the amount of R&D patents compared to the turnover of new products [23]. The amount of applied patents is a frequent indicator, sometimes related to R&D investments even if they are inputs and not accountable for the results. In addition, patents have drawbacks, such as [1]:

- An economic value that can sometimes be neglected
- A dependence on the habits of patent application, which varies in companies and countries.
- The fact that some patents are not used in innovations

- The fact that some innovations have no patentable content

This is why some authors investigated other indicators and results that can be assessed to determine the innovation capacity of companies.

2. Innovation Capacity

Bürgin offered such an assessment model [24], embodied in a questionnaire meant to be applied by companies themselves in a continuous way in order to define their improvement actions and go from the assessed status to their objective. These assessment questionnaires are formatted to fit the Meier's definition of the innovation capacity [25].

Bürgin also gathered influence factors, such as the degree of inventiveness (reached or desired), and their respective impacts on the different assessment modules. This additional information provides recommendations for an optimal goal setting considering the company context.

The 27 modules are designed to synthesize the following elements:

- The title of the given module
- An explanation on the general relationship between the assessed aspect and innovation capacity
- The current maturity status and the goal set for the given aspect
- The dependencies between the considered aspect and its influence factors
- Some relevant indicators in order to quantify the status
- Empirical or methodological literature references proving the relevance of the aspect

The table 1 gives the list of the modules allowing the assessment of innovation capacity within a company.

Table 1. Type and name of the innovation capacity assessment modules [24].

Type of module	Reference	Name of module
Strategy	1.1	Company and Innovation strategy
	1.2	Technology strategy
	1.3	Marketing strategy
Organisation	2.1	Decision making responsibilities
	2.2	Innovation-oriented organization
	2.3	Cooperation for innovation
	2.4	Collaboration with the customer
Process	3.1	Project management and audit
	3.2	Innovation process
	3.3	Idea management
	3.4	Innovation filters
	3.5	Use of method
	3.6	Market introduction planning
	3.7	Manufacturing planning
Resources	4.1	Financial resources
	4.2	Development resources
	4.3	Technology resources
	4.4	Production resources
Tools	5.1	Engineering tools
	5.2	Data integration
	5.3	Communication tools
Culture	6.1	General innovation culture
	6.2	Management alignment on innovation
	6.3	Innovation resistance
	6.4	Continuous training
	6.5	Communication styles
	6.6	Rewarding and motivation

Each of these modules provides an assessment on a scale going from a basic level, where the organization notice that the aspect as an impact on the innovation system, until a level of achievement and continuous improvement.

This model will then be used as a framework to define the potential and check the potential of improvement solutions. However, we still have no precise clues on a solution to be implemented to raise globally the innovation capacity of a company. In addition, this assessment has a few drawbacks, such as the fact that it does not provide a global scoring of the innovation capacity and does not take into account the relative importance of the assessed aspects and the effort required to make progress into them. Another innovation capacity model solved these last elements [3] and is seen as a good complement of the model of Bürgin, which has the widest view on innovation capacity and this is why we decided to keep it as a framework for this paper nevertheless.

3. Hints on Innovation Potential

After studying separate tools and methods to identify relevant solutions for global improvement, we focused on a reduced set of theories in order to increase the relevance of the actions to be implemented. It resulted in having TRIZ the best candidate for different reasons. Among these, a comparative analysis of Design Theories and Methodologies (DTM) highlighted the innovation potential of the theory[26], moreover since we wanted to be able to get potential complements (in case TRIZ revealed not to be perform ant enough), we appreciated the fact that TRIZ appeared to be a theory with multiple interfaces with other tools and finally that such combinations seemed to have a great potential (Cavallucci, 1999).

However, we consider that the tactical vision of the market, which is mandatory for market success (and therefore innovation performance), is not really facilitated by TRIZ approach because it tends to consider that a technical system evolves independently from its short-term market changes and opportunities. That is why we had interest in a second approach called Blue Ocean Strategy (BOS). This methodology brought by Kim and Mauborgne was born from the analysis of the context and requirements for great market successes. It resulted in the proposal of a set of tools and notions arranged in a detailed process to help replicating such successes. Such a methodology would have the interest to restore the full consideration of the market in the innovation challenge.

TRIZ and BOS approaches have similarities, in the sense that their creators looked for a way to determine, characterize and systemize the innovation process, in the field observation and empirical analysis. Altshuller decided to focus on the inventor and used an invention patent base to build his theory, while Kim and Mauborgne founded their analysis on the customer and witnessed market successes. This analogy, even with different study subjects, raised our attention, a fruitful innovation being the encounter of a new product or service and a market. This last comment gives a hint on potential interactions between these approaches.

4. Case study

4.1. Industrial context

The introduction of the European directive on Energy-related Products (ErP) is preparing the future environmental labelling of products such as appliances for central heating and domestic hot water production. This new referential tends to increase the offer of product with a lesser environmental impact, a reduced energy consumption and using a greater share of renewable energy.

We chose as a subject of experimentation the development of a hybrid heating appliance currently sold in France and known as “Mégalis Condens Hybride”[28], branded elm leblanc (which belongs to the Bosch group).

On individual and residential market, the analysis of the best performing solutions currently existing for central heating and domestic hot water production reveals essentially two technical solutions with similar performance and maturity levels: the technology of gas condensing boilers and the technology of electrical heat-pumps. However both of these technologies have specific benefits and drawbacks such as mentioned in table 2.

Table 2. Compared characteristics of a condensing gas boiler and an electrical heat pump

	Condensing gas boiler	Electrical heat pump
Benefits	Maturity of technology Compactness Independence from climate High power output	Increased efficiency with warm climate Share of renewable energy
Drawbacks	Maximum efficiency reached No share of renewable energy	Reduced efficiency with cold climate Reduced power output

On this basis, the new product concept had as an objective to be a compact heating appliance which would keep the complementary benefits of both of the technologies while reducing their drawbacks, mostly thanks its special architecture and control system.

Fig. 1. Megalis Hybride Condens[28]

This new heat generator allows a consequent reduction of both primary energy consumption and end customer energy bill by 10 to 20% compared to the latest gas-condensing boiler.

However, some technical challenges remain, mostly from the concept of a single envelope product and its reduced volume. Actually, the more the space available for the heat pump is reduced the harder it gets to maintain a low noise level and high energy efficiency.

4.2. Protocol

The experimentation was conducted with regular innovation capacity assessments according to the model proposed by Bürgin. We first established the starting level of this capacity (before any experiment) to check that we could have a measure of a potential improvement. Indeed, if the innovation capacity were already too high, it would be difficult to witness any enhancement. Then, several sessions were conducting using classical TRIZ based on the analysis of the hybrid heating appliance current design, followed by a new assessment of the innovation potential to derive the benefits of TRIZ. Then a second series of workshops occurred to analyse some of the strongest remaining improvement potential of the appliance design, where this time, TRIZ was combined with some of BOS tools and methodology. A last innovation potential assessment revealed what were the additional valuable outputs.

4.3. Results and analysis

The first deployment of TRIZ in the organisation generated deliverables such as:

- The documentation of the technical system (understanding and analysis of the current design and similar systems) at both functional and structural levels.
- The analysis and sharing of knowledge among the teammates and the identification of the missing and required fields of expertise.
- The quantified expression of the ideal system and the path of the product development.
- A synthesis of all the models of problem encountered (as technical and physical contradictions) that need to be solved.
- A folder of documented ideas allowing both collection and traceability of all the ideas generated during the workshops.
- A multi-criteria assessment allowing the identification of the most promising ideas.
- A multi-screen analysis documenting the evolutions of the system, its super system (heating system and house in our case) and its subsystems (appliance components such as the control unit and the heat exchangers).

The Fig. 2 shows the results of the initial assessment of the innovation capacity and the results obtained after the first introduction of TRIZ. The maturity levels (2009) and (XP TRIZ) represent maturity level partially acquired. The assessment modules refer to the list presented in the Table 1.

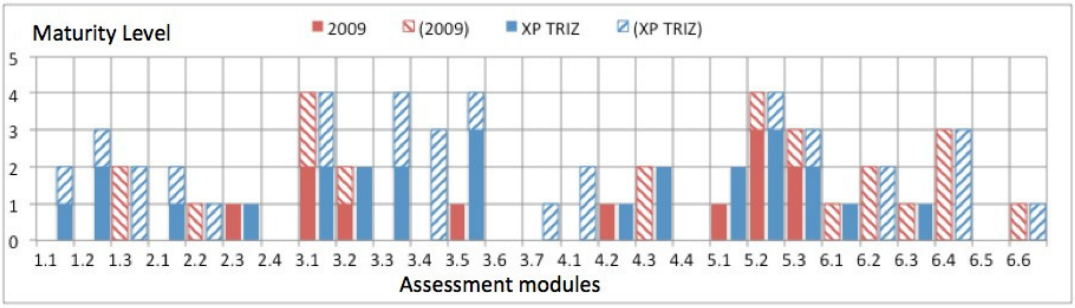

Fig. 2. Comparison between the initial innovation capacity and the assessment after the first introduction of TRIZ

The multi-screen analysis was the tool that generated the most valuable outputs in this experiment. It granted a new vision of the hybrid technology and some other internal new technologies in a relevant and logical framework. This vision became the basis for the deployment of new predevelopment activities.

Regarding the framework of innovation capacity assessment, the greatest improvements of these first workshops (by comparison of the results before and after the sessions) were noticed in the « Strategy » and the « Process » fields. The strategy assessment modules show the benefit that the multi-screen analysis had on the description of the major technological evolutions that the product will have to face and derived research fields, and the finding of the future issues to be solved through the pursuit of the ideal. The innovation process was improved thanks to the use of relevant and detailed idea templates and multi-criteria assessment. This gathering of ideas is not intrinsically linked to TRIZ, but this approach granted a robust traceability while reporting for each idea:

- The initial formulation of the problem to be solved
- Its reformulation in the format of a technical or a physical contradiction
- In the case of a technical contradiction, the parameters and the innovation principle used to solve it
- In the case of a physical contradiction, the separation principle used to solve it

This first experimentation highlighted that TRIZ had a positive effect on the innovation capacity, even though issues were encountered during this roll out mostly due to the complexity generated by the fact that several systems were studied during the sessions (and not only the presented hybrid heating appliance) and also due to the involvement of several nationalities of participants which slowed the flow of ideas and the possibility to share the knowledge. Therefore the overall efficiency was reduced. These lessons were taken into account for the next workshops.

It is also important to notice that the assessed aspects related to the customer and the market such as the « marketing strategy » and the « collaboration with the customer » reveals low scoring with the use of TRIZ only. We consider that the Blue Ocean Strategy approach can provide enhancement on these.

The boundaries of the second experimentation were defined more precisely than previously. The detailed analysis was guided by the outcome of the product strategic canvas, coming from the Blue Ocean Strategy analytical toolset, which precised the highest stakes for a proper focus and differentiation of the product compared to competitors. The new contradictions were more detailed and the results of these new workshops (in terms of ideas gathered) were far more explicit and valuable. After 4 days of sessions with the team, a great amount of ideas (103 ideas were detailed) was available and 54% of them were assessed as applicable in less than a year of development and some were applied on a very short term (a few months after the workshops). The use of the strategic canvas appeared to be a great compass that proved to be complementary with the pursuit of Ideal Final Result. This approach was also combined with the application of the 3 first evolution laws on some of the subsystems of the appliance. Several external experts were also involved in this second application of TRIZ and the theory showed qualities in the precise understanding of the physical phenomenon involved.

The Fig. 3 shows the previously analysed results and gives a comparison with the combined deployment of TRIZ and Blue Ocean Strategy (BOS). The maturity levels (2009), (XP TRIZ) and (XP BOS+TRIZ) represent maturity level partially acquired. The assessment modules refer to the list presented in the Table 1.

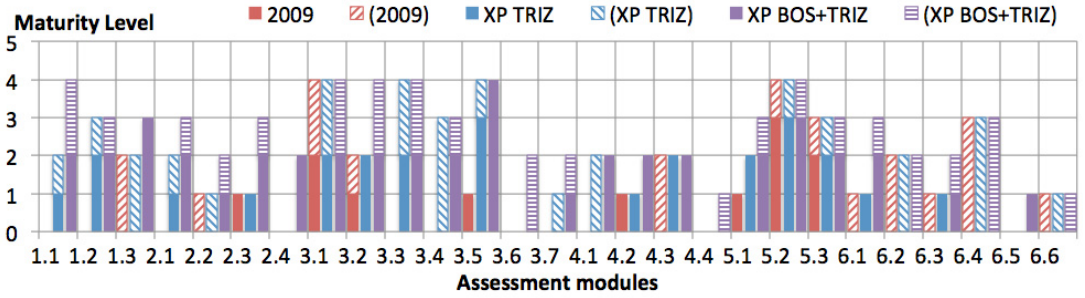

Fig. 3. Comparison between the initial innovation capacity and the assessments after the first introduction of TRIZ and the combined TRIZ and BOS experimentation.

The combined application of TRIZ and BOS emphasized the importance of both the technical and marketing competences required in the decision making process. The involvement of external experts (from industry and universities) showed how the company could benefit from a greater cooperation for innovation and an optimized allocation of development resources. The progress regarding the innovation process was also consolidated, as the second series of workshops appeared to be consistently reproducible and efficient to derive and solve technical challenges from a defined differentiation strategy in the market.

However, potential for improvement remains according to the last assessment of the innovation potential. A closer collaboration with the customer, as theoretically emphasized with the Blue Ocean Strategy but not conducted during these experimentation, would improve the « Organisation » field assessment. Similarly, the poor score shown in the « Production planning » assessment module can be explained by the reduced implication of production spokesperson in the workshop teams (which were mostly composed by R&D employees). Therefore this is also a hint for further innovation capacity construction.

Even though we can notice that TRIZ and BOS, applied in an industrial context, considerably raised the innovation capacity, the cultural aspects of innovation capacity could be considered as a bit disappointing. We

currently consider that the reduced impact of the experimentation on innovation culture is due to the fact that the sharing of the experience with the whole organisation was not done yet and can be explained by the small groups and workshop type of introduction of TRIZ and BOS. We still believe that a wider roll out of both of the approaches will be possible with a formalised process and the first visible outcomes of the presented experimentation.

5. Discussion

This paper was an attempt to detail the benefits that TRIZ can have on innovation performance, besides the generation of technical solutions to a given innovation problem. It resulted in the use of an assessment framework based on innovation capacity of companies. This approach of innovation performance helped a lot on the recognition of all side effects of the experimentation. In addition, this framework provides a set of recommended indicators to describe further each of the different facets of the innovation capacity. Our belief is that such a protocol resulted in a more objective assessment and we encourage similar experimentation for benchmark and not only with TRIZ and BOS but for any other DTM or even tools that can be proposed for innovation capacity construction.

The combination of BOS tools and notions with TRIZ brought a higher implication of the whole group in the solving process, because of this market guidance. These exchanges between the approaches were well received by the group and we consider that they can be extended.

The conducted experiments revealed that TRIZ and BOS are not magical wands, since they do not grant instantly a top-level innovation capacity. However, they provided a great improvement and we could identify that TRIZ and BOS could be complementary, both on macro scale (by showing improvement in different fields of the innovation capacity) and on micro scale (with a set of tools and notions that could be combined). The attitude towards innovation also changed during the whole experimentation phase switching from a reactive attitude to a proactive attitude (according to another assessment method [3], not developed further in the paper).

This association makes a lot of sense to us as it restores the completeness of the innovation act: bringing a new and relevant technical solution of an inventive problem into the market while making assuring the market relevance of the idea for the proper differentiation of the product.

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